TSM-Bench: Benchmarking Time Series Database Systems for Monitoring Applications

Abdelouahab Khelifati, Mourad Khayati, Anton Dignös, Djellel Difallah, Philippe Cudré-Mauroux

VLDB’23, Vancouver – Canada

August 30, 2023
Monitoring Application

- BAFU\(^1\) use sensors to monitor the water quality in Swiss rivers.
- The collected time series are multivariate with different features.

\(^1\) Federal Office for the Environment in Switzerland
Monitoring Requirements

- Monitoring hydrometric time series involves various analytical tasks: data exploration, anomaly detection, forecasting, trend analysis, recovery of missing values, and similarity search.

- Traditional RDBMs are ill-equipped to handle analytical tasks.

- Time Series Database Systems (TSDBs) are specialized systems that store, manage, and query large time-series data.

- Picking the best TSDB remains a challenge.
SOTA & Contributions

- Existing TSDB benchmarks implement:
  - Static queries on a subset of relevant systems.
  - Ingestion and querying in isolation.
  - Simplistic data generation, if any.

- TSM-Bench benchmarks seven popular time series systems by providing:
  - Dynamic query evaluation using offline and online workloads.
  - Realistic time series generation technique.
  - Recommendations for understanding and navigating the architecture of systems.
TSM-Bench

Evaluation

Recommendation
TS-LSH uses sample data to generate large realistic data streams.

The executor launches configurable workload tiers.

The statistics collection module records the performance of the TSDB.
GAN takes an input time series partitioned into segments.

Concatenating segments using GAN is exponential.
TS-LSH augments both the length and the number of time series.

TS-LSH is sub-linear with the input and linear with the output.
Current Section

TSM-Bench

Evaluation

Recommendation
We designed the workloads around three performance dimensions:

- Size of input/output data, data access, and the number of operations.
- Interplay between querying and ingestion.
- Impact of time series features on compression performance (data encoding).
Experimental Setup

- **Systems**: ClickHouse, Druid, eXtremeDB, InfluxDB, MonetDB, QuestDB, and TimescaleDB.

- **Datasets**: Two datasets (#sensors, #stations, range)
  - D-LONG: $10 \times 100 \times 60$ (518M datapoints)
  - D-MULTI: $2k \times 100 \times 10$ (17.2B datapoints)

- **Offline workload**: 7 queries (Fetching, Fetching with Filter, Aggregation, Downsampling, Upsampling, Cross-sensor Average, and Correlation).

- **Online workload**: Queries execution under concurrent ingestion.

- **Compression workload**: Storage size under various time series features.
Offline Workload

Aggregation & Downsampling

```sql
SELECT st_id, AVG(s_i)...AVG(s_j) Agg
FROM ts_table
WHERE st_id in <st_list>
AND time < ?timestamp
AND time >= ?timestamp - ?range
GROUP BY st_id;
```

![Chart showing query runtime for different databases and query ranges.](chart)

- eXtremeDB and TimescaleDB are the fastest in case of simple aggregation.
- eXtremeDB and ClickHouse are well-suited to downsample data.
Queries do not block writes for all systems.

- QuestDB and ClickHouse are the best for low insertion rates.
- InfluxDB and MonetDB provide the best runtimes for very high insertion rates.
Compression Workload

- All systems benefit from the existence of repeats.
- Only ClickHouse and Druid can take advantage of the existence of missing values.
Current Section

TSM-Bench

Evaluation

Recommendation
Seven discriminative dimensions for comparing the performance of TSDB.
The performance of each system for different query types is ranked on a 0-5 scale.
No silver bullet system.
Architecture Impact

No single architecture dominates all the workload tiers

Design factors:
- Offline workloads: query selectivity and the size of the data
- Online workloads: Insertion rate and the query selectivity

(a) Offline Workloads

(b) Online Workloads
Conclusion

- TSM-Bench is a comprehensive benchmark for TSDBs.

- We provide a fine/coarse-grained recommendation for decision-makers at different levels.

- The code is open-source.

- Future work includes mixed-queries workloads and multitenancy scenarios.
TSM-Bench: Benchmarking Time Series Database Systems for Monitoring Applications

Abdelouahab Khelifati, Mourad Khayati, Anton Dignös, Djellel Difallah, Philippe Cudré-Mauroux

Thank you!

abdel@exascale.info

Questions?

https://github.com/eXascaleInfolab/TSM-Bench